Rail Research Increases Safety and Saves Dollars

Association of American Railroads and Federal Railroad Administration

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Safety concerns are a major impetus for advances in railroad technology. This has been the case since the 1970s, when the railroad industry's research program, conducted through the Association of American Railroads, was expanded to develop technology to increase safety. An industry-wide collaborative research effort conducted by the association and the Federal Railroad Administration, together with the railroad-supply industry and the government of Canada, laid the groundwork for today's railroad-safety technology by advancing understanding of the scientific and engineering underpinnings of heavy-freight rail operations. This research effort has played a significant role in improving the industry's safety record, reducing the train-accident rate by nearly 60 percent since 1980.

Much of the research that led to today's enhanced railroad safety was conducted at the Transportation Technology Center, located near Pueblo, Colorado. This federally owned, Department of Transportation facility is operated and maintained by the Research and Test Department of the Association of American Railroads under an agreement with the Federal Railroad Administration. A unique, world-class intermodal research center, it offers the railroad industry extensive investigative, technology-development, and testing capabilities.

Below are highlighted the Heavy Axle Loads Program, the Roller Bearing Defect Detection Program, and the upgrade of a high-speed rail test track. Three of many research efforts at the Transportation Technology Center, they will yield significant long-term benefits.

Effects of Heavy Axle Loads on Performance

Operational since 1988, the Heavy Axle Load Program focuses on the effects of increased axle loads on the performance of railroad tracks and vehicles. The program is jointly funded by the Federal Railroad Administration and the Association of American Railroads and is supported by the railroad industry through donations of locomotives, rolling stock, and track materials. A task force of representatives from the agency, the association, the railroad-supply community, and railroad engineering departments directs the program and provides technical oversight.

The objective of the Heavy Axle Load Program is to quantify, through full-scale testing, the safety and economic costs of operating 35-metric-ton (315,000-pound or 39-ton axle load) freight equipment. Track performance is measured at the Facility for Accelerated Service Testing, where a train of 78 fully loaded, 117 571-kilogram (259,200 pound) freight cars runs along a 4.35-kilometer (2.7-mile) high-tonnage loop. Operation of the train approximates 137 metric tons (150 million gross tons) of traffic annually, allowing researchers to determine track-component and track-system wear rates, fatigue lives, and degradation/failure modes in a controlled environment.

Before 1995 the train was equipped with standard-design three-piece freight-car trucks (suspension systems). After operating the train to approximate 417 metric tons (460 million gross tons) of standard truck traffic, researchers came to two conclusions. First, 35-metric-ton axle loads could be accommodated by a standard track structure, but the cost of maintaining the track would increase

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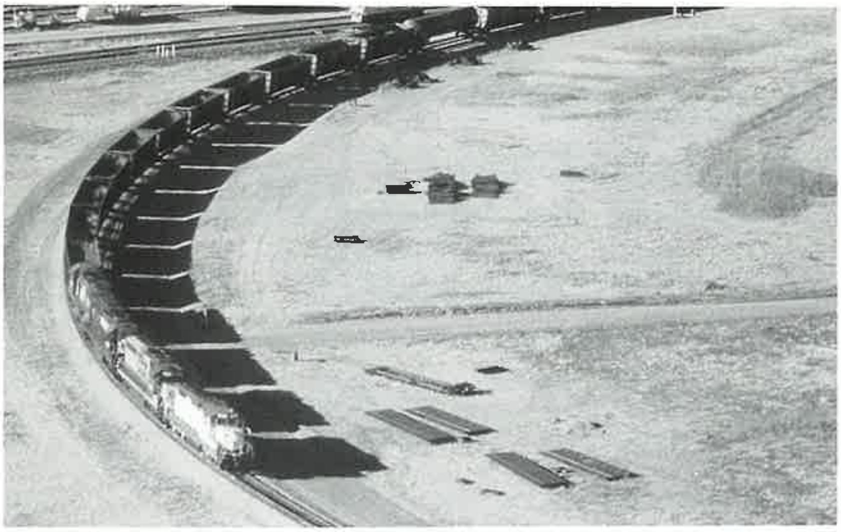

ASSOCIATION OF AMERICAN RAILROADS

Track performance under heavy axle loads is measured at Facility for Accelerated Service Testing at Transportation Technology Center, located near Pueblo, Colorado, during study to quantify safety and performance benefits of trucks with improved suspension.

approximately 30 percent. Second, the use of premium track materials could reduce the maintenance-cost penalty to about 23 percent and significantly improve operational safety.

Much of the track deterioration and safety problems associated with increased axle loads were found to be related to the lateral forces generated when standard-design trucks negotiate curves. In 1995 the current phase of the Heavy Axle Load Program was implemented to determine the safety and performance benefits of trucks with improved suspension. The train was re-equipped with new trucks designed for improved curving response through enhanced wheel-set steering capability. After a year of tests with 136 metric tons (150 million gross tons) of applied tonnage, researchers concluded that lateral forces and wheel set angles-of-attack measured on medium-degree curves (or a 305-meter or 1,000-foot radius) are approximately 50 percent of those measured previously with standard-suspension trucks on the same curves. They also found that rail wear on medium-degree curves was significantly reduced. Rail corrugations on curves, which were visible at 54 metric tons (60 million gross tons) of standard-truck operation, were not evident after 136 metric tons of improved suspension-truck operation. In addition, fuel consumption measured on the high-tonnage loop was reduced by at least 25 percent, and degradation of softwood ties on curves (track gauge widening) was also reduced by slightly more than 50 percent as a result of improved curving characteristics.

It should be noted that the savings in fuel and track-damage costs achieved at the Facility for Accelerated Service Testing may translate into fewer but still significant savings in actual revenue service. This may be the case because the experiments at the facility are well controlled, and the track (approximately 75 percent curves) and equipment-maintenance procedures are unique to the operating environment at the facility. However, data from the facility have enabled engineers at the Association of American Railroads to determine, for the first time in recent railway research, the savings in track and operating costs resulting from improved truck-suspension systems.

Detection of Roller-Bearing Defects

Each year 40 to 60 derailments result from the overheating of wheel roller bearings on rail cars. To guard against such failures, the railroads have expended extensive capital to deploy a network of wayside hot-bearing detectors. Although these detectors have prevented many additional failures, the overall performance of the network has been less than satisfactory. In the majority of train stops caused by hot-bearing detectors, train crews find no defective bearings. However, hot-bearing failures often occur within a few miles of an operational detector system. Therefore, the Association of American Railroads, in conjunction with the Federal Railroad Administration, undertook the Roller Bearing Defect Detection Program to improve wayside bearing-defect detection. The ultimate objective is to demonstrate and promote development of an advanced-performance acoustic wayside roller-bearing detection system, thereby reducing bearing-related derailments.

Most bearings fail after months of operation; they occasionally fail rapidly and catastrophically, raising axle temperatures sufficiently high to soften steel and derail a train in a matter of minutes. In these cases, the danger signs, primarily high temperatures and loud noises, arise quickly. Therefore, a key program goal is to develop technology to identify those cool, quiet bearings that are about to suddenly fail.

To transform bearing-defect detection into a predictive maintenance function, a data base of defective bearing signatures, both in the laboratory and in the field, was needed. This effort involved not only the Research and Test Department of the American Association of Railroads, but universities, national laboratories, and the railroad-supply industry as well. Laboratory testing of good and defective bearings and field testing of trains with defective bearings were completed in 1996. The resulting data base is now being used at the Transportation Technology Center to develop advanced signal-processing techniques to identify the type and severity of bearing defects.

The objective of the laboratory testing was to determine whether acoustic techniques could be reliably used to identify specific bearing defects. Specific bearing defects of primary importance for detection were identified through the polling of railroad departments. These defects were the focus of the laboratory testing and a simulated revenue-service field test.

New signal-processing and -detection techniques are being developed at the Transportation Technology Center to produce a new-generation acoustic wayside bearing-defect detection system. One of the signal-processing techniques being applied is envelope detection. A raceway (surface) defect or anomaly of any kind will produce shock pulses that repeat at a characteristic or bearing-component rotation frequency. Through envelope detection, these pulses can be extracted and demodulated into bearing-component characteristic frequencies.

Another technique involves the use of neural-network analysis of enveloped and otherwise preprocessed acoustic data. Neural-network technology is a computational process that simulates biological brain neurons. Neural networks are particularly applicable to classification and pattern recognition. Frequency-domain spectra from acoustic signals collected by a wayside detector can be fed into a neural network to train it to learn bearing-defect patterns. If an incoming signal matches one of these patterns, the detector will send out a warning signal. The decision to pull the bearing can be made on the basis of preset levels of severity in conjunction with other information, such as temperature.

The simulated revenue test with defective bearings will be used to further develop and refine advanced detection methods on the basis of the challenges imposed by a moving defect on a freight car. Once the development process is completed, demonstration tests will be conducted.

Upgrade of Railroad Test Track for High-Speed Rail

The U.S. Department of Transportation is assisting various state agencies and transit and commuter rail authorities to improve and expand passenger-rail capacity. The efficient and cost-effective use of research and testing resources to evaluate vehicles, infrastructure, and signal systems in a high-speed environment will play an essential role in the successful and timely implementation of high-speed rail initiatives.

An objective of the Federal Railroad Administration's Next Generation High Speed Rail Program is to develop systems meeting speed, capacity, performance, and safety criteria. The program must ensure the timely, efficient, and safe introduction of these systems into commuter and intercity service and the long-term popularity of the vehicles with customers. An independent test and assessment of entire systems using performance-based criteria in a controlled, full-scale, on-track testing environment is essential to achieve compliance with the overall objectives of the performance test.

Typical performance-testing regimes include vehicle suspension characterization and evaluation of track worthiness, structural integrity, ride quality, propulsion/brake system performance, and environmental impacts. As part of the Next Generation High Speed Rail Program, the Transportation Technology Center's railroad test track is being upgraded. The track, with overhead alternating-current catenary power, allowing operation of vehicles at a maximum speed of 266 kilometers (165 miles) per hour and sustained running speeds of 241 kilometers (150 miles) per hour, will be used for initial tests and evaluation of new high-speed trainsets designed for Amtrak's northeast corridor operations. The track will then be available for performance testing and evaluation of high-speed rail equipment and technology planned for future, major intercity high-speed corridors. During upgrading of the 21.7-kilometer (13.5-mile) railroad test track, expected to be completed late this year, the overhead catenary system will be rehabilitated, and a new rail-integrity signal system will be installed to detect broken rails, open switch points, and other faults.

Looking Toward the Future

The Heavy Axle Loads Program, the Roller Bearing Defect Detection Program, and the upgrade of the Transportation Technology Center's high-speed-rail test track are among the research efforts making railroads the safest and most efficient choice to meet the transportation needs of the future. The success of these and other projects at the Transportation Technology Center hinge largely on the cooperation of the federal government and the railroad industry. This cooperation ensures that research efforts address issues critical to the North American rail industry and that resources are most efficiently deployed. The continued commitment of the Federal Railroad Administration to projects at the Transportation Technology Center, and the identification of cost-effective railroad technologies and designs by the American Association of Railroads, will be key factors in the continued development and implementation of freight and high-speed rail systems meeting capacity, performance, and safety criteria.